# Horizontal & Vertical Variation Shield Method

Freely spiraling or separating a tunnel of multi-circular cross section

Characteristics

1. Cross section can be changed continuously from horizontal to vertical multi-circular shape or vice versa.

The cross articulation system enables free control of machine steering and orientation, and continuous change of multi-circular cross section from horizontal to vertical alignment or vice versa.
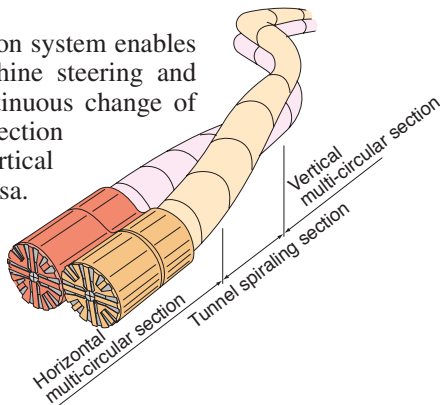
2. Separate tunnels can be constructed without driving a vertical shaft.

Separating the shield machine under the ground surface enables the construction of separate tunnels without driving a mid-tunnel vertical shaft.
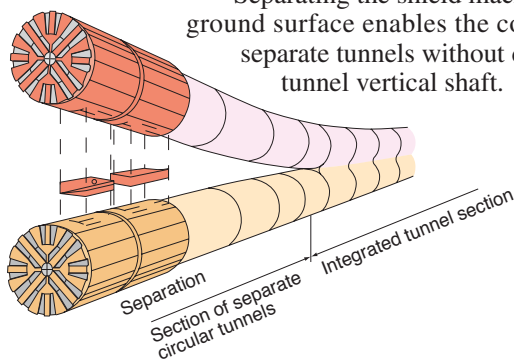
3. Construction period can be shortened.

Simultaneous construction of multiple tunnels and elimination of a mid-tunnel vertical shaft for constructing separate tunnels contribute to shorter construction period than that required for conventional methods.

4. Costs can be reduced.

Costs can be reduced because work for improving the ground or driving a mid-tunnel vertical shaft required for constructing adjacent multiple tunnels or separate tunnels can be reduced considerably or eliminated completely.

Mechanism of tunnel driving

Cross articulation system

The cross articulation system articulates multiple front bodies of a shield machine in reciprocal directions and make respective bodies advance in different directions. The system enables shield machine to generate rotating forces and advance so that the tunnel spirals.
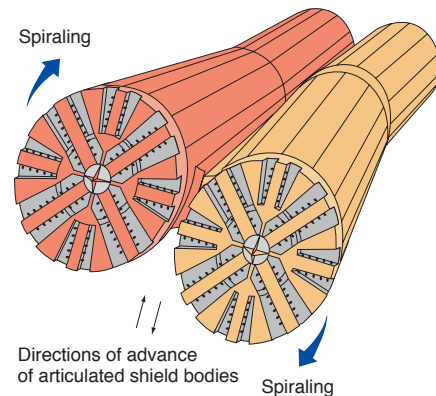
Integrated segment

Spiraling tunnels can be constructed using integrated segments in the section where two tunnels are combined and twisted. Segments for ordinary single-circular tunnels can also be used for constructing separate close tunnels.

▲ Integrated segment

Applications to actual tunneling

▲Construction of the Minami-dai main sewer

◀ Diameters of shield machines for constructing vertically separated tunnels
    Upper shield: 3.29 m
    Lower shield: 2.89 m
Type: Slurry shield
Length: 154 m (vertical multi-circular section)

▶ Diameters of four-centered circular shield machines for constructing the station
    Main shield: 6.56 m (left and right shields)
    Sub-shield: 1.72 m (upper and lower shields)
    System dimensions: 13.18 m wide and 7.06 m high
Type: Slurry shield
Length: 118 m x two tunnels

▲ Construction in the Roppongi station work section in a loop on subway line No. 12